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ABSTRACT

A heuristic model designed to improve creative problem-solving by engineering students was studied. Ten students majoring in industrial engineering were pre-tested to establish the range and accuracy of their performance prior to training and to identify stereotyped thinking. The test was an adventure scenario with 50 embedded problems along with a performance problem that required the student to build a simple machine designed to solve a specific performance problem. After demonstrating that thinking has a tendency to become stereotyped, students were shown processes for revising the stereotype, discovering the components of a problem, and analyzing the component patterns within the problem. Training included lecture, demonstration, discussion, and application. Students were expected to see the relationship between the differentiation processes and the associations or patterns that could be developed from the parts. The model was effective for 60 percent of the students, while the other 40 percent showed positive change even though they did not achieve a significant level of change. It is concluded that certain basic processes involved in creative problem-solving appear to be easily stimulated and developed with this short-term stimulation technique. (SW)

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Experimental Model for Stimulating Creative Problem Solving by Engineering Students

by

Harold L. Hayes

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of the
American Psychological Association

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The modern technological world is a highly competitive arena. At the heart of this arena is a group of professionals whose achievements have a far reaching economic and political impact. These achievements depend upon the capacity of the members of this profession to constantly refine their thinking processes and generate even more creative results.

Yet, it is apparent that engineers are expected to come into the field knowing how to think and create, or they are expected to learn these processes from their profeesors, who as experts in engineering, most likely have not mastered enough psychology to clearly articulate their own creative thought processes and certainly lack the background to teach these processes to others in the form of clear, meaningful, dynamic models (J.T. Woolsey, Personal Communication, January, 1983).

In fact, engineering may be limited more by this single barrier than any other set of problems besetting the field (Chronicle Higher Education, 1984).

The questions, thus, must be asked: Are there mental models, heuristics and strategies that can enhance the power, precision and creativity of the engineer's thinking processes; further, are these models and heuristics economical in terms of the amount of time required to stimulate their functioning?

There is no question about the power and validity of mental models in human thought (Centner & Stevens, 1983). The question is: Have we designed here a heuristic of exceptional power that is also cost effective and easily taught?

This paper reports on a heuristic design that was shown to significantly enhance the precision, power, and creativity of problem solving in engineering students. The heuristic studied in this research is a component of a more comprehensive model which is described elsewhere (Hayes, 1984).

The object of this experiment was to isolate, as well as possible, a single heuristic, which I have termed the decision making heuristic, and test its effectiveness. Figure 1 shows the hierarchial position of the heuristic relative to the model and heuristic sub-components.

It is important to point out that mere knowledge of the isolated terms comprising the heuristic is ineffective for operational level creativity and problem solving. The power is in the heuristic as a whole.

The Problem

The nature of the problem then is to test the effectiveness of the experimental model in stimulating the ability of engineering students to develop and apply creative problem solving processes.

The Research Hypothesis

Training on the experimental model will significantly enhance the creative problem solving performance of the students at the .05 level or less.

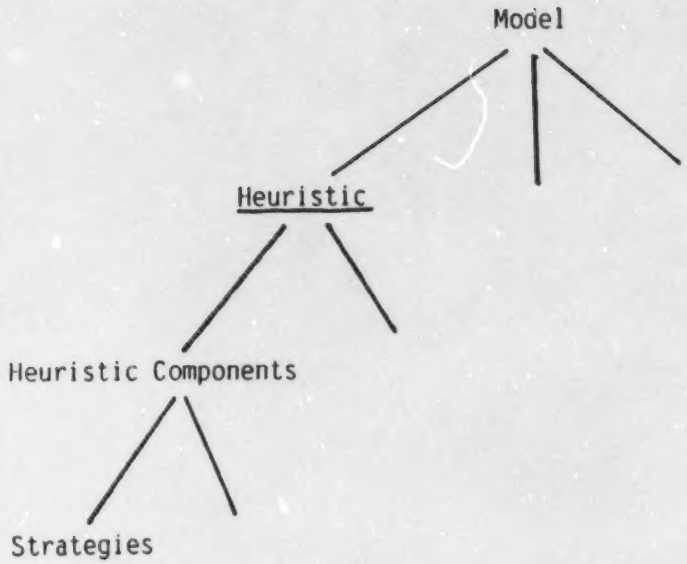
Subjects:

There were ten subjects in the sample which was comprised of college level students majoring in Industrial Engineering.

Procedure

The experimental model consists of two major parts: 1) the measurement component and, 2) the traini.g component.

The subjects were pre-tested to establish the range and accuracy of their performance prior to training and also to identify stereotyped thinking which was to be addressed during the training process.



Hierarchial Position of Model Components

Figure 1

The test was designed as an adventure scenario with fifty embedded problems that were to be solved by the student as he/she read the scenario. Also, the test contains a performance problem which required the students to build a simple machine des gned to solve a specific performance problem. The materials for the performance problem are standard and were provided in a packet with the test.

The Model

The heart of the training is the experimental heuristic which, it is hypothesized, is inherent and can be quickly stimulated into effective, conscious level functioning (Figure 2, Hayes, 1984).

Training

THe first step in the training procedure is to demonstrate that thinking has a tendency to become stereotyped. Certain educational processes tend to reinforce this.

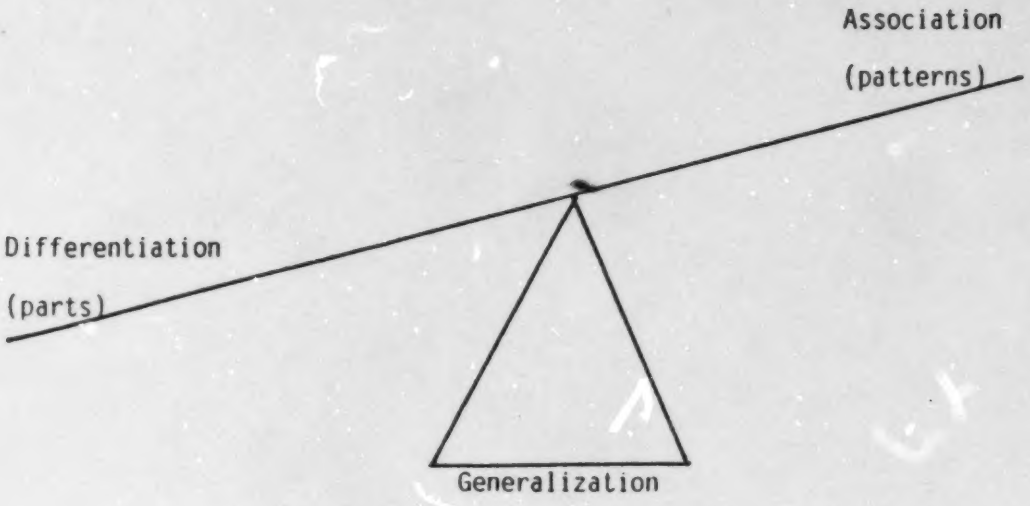
We then demonstrate the processes present within the heuristic for shattering or revising the stereotype, discovering the components of a problem, and analyzing the component patterns within the problem.

The content of the training covers the five topics in figure 2. Each topic is defined. Then the students are presented with a problem that illustrates the topical concept.

A typical differentiation problem requires the students to identify the facts in the problem situation. The problme may be a short scenario, a geometric or spatial relations problem. The purpose of the training is to stimulate the use of strategies to enhance fact finding, i.e. finding parts of a problem.

Recognition

(stereotypes)



Decision Making
(evolution)
(changes)

The Decision Making Heuristic

Figure 2

By embedding the test and training models within self-explanatory material, we were testing only the experimental processes and not experiences the individual may not have had.

Training includes lecture, demonstration, discussion, and application. In addition to a verbal test, manipulative and constructive materials are provided for the construction of a creative device which is necessary to solve a major problem in the training exercise.

In this manner, the training progresses through each component of the heuristic. The final stage of training requires the dynamic application of the entire model.

As the design of figure 2 illustrates, the students were expected to see the relationship between the differentiation processes and the associations or patterns which could be developed from the parts. This relationship is clearly dynamic, and, once understood, helps the student overcome the tendency to let his memories and powers of recognition suggest to his/her mind a ready answer which then seems to control or exert a strong biasing tendency on the solutions considered. That is: once the student sees a pattern in the data or facts under consideration, the tendency is to accept that as the solution and move on to another problem. This is literally an unreasoning approach, but its origins can readily be seen in the educational practice at the elementary and secondary levels. What is so remarkable is that this condition can be corrected so quickly.

This is gradually corrected with activities that prevent stereotyping, sharpens differentiation of details, and leads to generalization of details into the patterning function and the subsequent development of new patterns.

Results

Using the t test to evaluate the difference between the means of the pre-test and post-test, we found that approximately 60% of the students showed an improvement in the application of the creative problem solving processes. This was significant at the .025 level or less.

The students discovered that they were not identifying the details of problems and furthermore, they discovered that even it they knew to look for details, they had no sophisticated means of doing so. Generally, they just "looked" until they found something then they did something with it. Certainly, little care was given, prior to training, to elegance of solution design.

With hands-on activities and immediate feedback, they quickly learned to utilize the heuristic and the concomitant controls to see reality and to repattern what they saw.

Conclusions

1. The model was effective for 60% of the subjects involved.
2. The other 40% of the students showed positive change from the stimulation even though they did not achieve a significant level of change.
3. Certain basic processes involved in creative problem solving appear to be easily stimulated and developed with this short term stimulation technique.
4. More extensive research is needed to refine both the experimental design and the model.

Implications

The model, as it exists, can significantly enhance the intellectual performance of the majority of engineering students with little or no increase in the cost of their education.

Further, I would suggest that the benefits of this degree of intellectual improvement in terms of organizational competition in the marketplace is not just the difference between surviving and failing, but the difference between just surviving and being a leader in the field.

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